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FIBRE YIELD DETERMINATION THROUGH NIR AND OTHER LAB PROCESSING METHODS

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Final Report

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Fiber Yield Determination through NIR and Other Lab Processing Methods

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Executive Summary

Background

Recent market surveys and on-going research indicate that there are many potential products that could utilize flax fibers to complement or replace glass, synthetic and cotton fibers. However, processing flax straw into industrial-grade fiber is not profitable if the fiber content of the straw is not high enough. An inexpensive, accurate and rapid method of determining fiber content in flax straw is needed to help farmers, processors, flax breeders and potential investors profitably grow and process flax fiber in the province. ADF and Saskatchewan Flax Development Commission-funded projects assisted Biolin Research to develop a proto-type Near InfraRed (NIR) system to estimate the fiber content in unretted flax stems. This system was available and functional for use in tests carried out in the winter of 2002/2003 to determine the fiber content of flax straw samples collected from research plots across Saskatchewan and Manitoba in the fall of 2002. A manual fiber extraction procedure previously developed by Biolin Research was used to compare the results of the NIR procedure.

Objectives

The objectives of this study were to:

1. Give producers, processors, breeders and potential investors the information they require to create profitable flax fiber based industries in Saskatchewan, and

2. Determine how a processor's fiber yields can be affected by location, variety and agronomic practices.

Experimental Methods

Over 600 straw samples were collected from 12 widely separated research plot locations. At each variety test location, a selection of 22 varieties was replicated three times in randomized plots. Straw from each plot in each trial was pulled out of the ground by hand after the seed was harvested. When possible, the samples were weighed to estimate the amount of straw that could like be salvaged on an equivalent per hectare basis. From each straw sample collected, a sub-sample bundle of straw 4.0 cm in diameter was selected. Each sub-sample bundle was then cut 10.0 cm above the ground level mark and 19.0 cm higher up resulting in bundles that were 19.0 cm in length. After cutting, each sub-sample was weighed and then analyzed for bast fiber content by NIR technology. Fiber yields, on a per hectare basis, were calculated by multiplying the bast fiber content generated by the NIR system, by the estimated amount of salvageable straw per hectare.

To compare these NIR results with manual method results, selected samples were retted in a warm water tank for four to six days until the results of the "Fried Shake Test" showed that the majority of bundles were optimally retted. The bundles were then taken out of the tank, rinsed, and set in racks to dry. The fiber was then extracted from each dried, retted, sub-sample using a reciprocating blade-type breaker/decorticator. The fiber was hand cleaned to the point where few or no shives were left. After cleaning, the fiber was weighed. The percentage of bast fiber in the straw was calculated by taking the

clean fiber weight, dividing by the weight of the unretted straw and multiplying by 100. This result was compared with the NIR results from the original sample.

Results and Discussion

Many of the Saskatchewan locations experienced unusually dry weather in 2002 and, hence, plant height, seed yield and fiber content were much lower than normal. The Crop Development Centre decided not to harvest five of the poorest performing sites. Fortunately we were able to collect straw from some Manitoba Agriculture sites to replace straw samples that could not be collected from the abandoned Saskatchewan Regional Trial sites. There were statistically significant differences in bast fiber content and fiber yield among most of the locations and often between varieties at the same location. Results indicated that some varieties with superior fiber content and seed yield in 2001 were inferior in 2002. Further years of testing are needed to sort out how consistent supposedly superior fiber content varieties are over a number of years with varying growing season conditions. Both the NIR and manual methods of bast fiber determination that were used in this project are still being developed and refined and neither method is highly precise at this time. Each has associated with it, sources of variance and error that are not always correlated with the alternative test method. Hence, the results of NIR and manual methods used in this project were often, but not always, relatively similar. Both are suitable for separating straw into high, medium and low levels of bast fiber content but neither will be highly precise until further research and development work takes place to improve their precision.

Conclusions and Impact

We do not know how much bias and misleading information was generated by the dry conditions in Saskatchewan but there were significant differences between Saskatchewan and Manitoba fields on a whole. Varieties do often influence fiber content and hence farmers can influence fiber content of oilseed flax by their choice of variety. However, more years of data are needed to improve our ability to predict which varieties will generally be superior. Both the NIR and manual methods of bast fiber determination used in this project would be suitable, in most cases, to distinguish straw with high, medium or low bast fiber contents but both types of tests need more refinement to make them more precise. Given such a wide range of fiber contents, it is obviously very important for processors and producers of flax straw and breeders of flax varieties to have methods that will allow them to quickly choose straw that has superior fiber content.

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Abstract

Near InfraRed (NIR) and manual processing methods were used to measure the bast fiber content of straw samples of 22 flax varieties grown in various combinations at 12 sites in Saskatchewan and Manitoba in 2002. Results showed that location and/or variety can have a significant effect on bast fiber content. Both the NIR and manual methods of bast fiber determination used in this project would be suitable, in most cases, to distinguish straw with high, medium or low bast fiber contents but both types of tests need more refinement to make them more precise.

Technical Report

Background and Objectives

Background

Farmers in Saskatchewan seed 350,000 to 450,000 ha of oilseed flax every year to produce seed destined mostly for export. Between 800 to 1,200 kg/ha of straw could be collected after the seed is harvested. At present only 10-15% of this straw is salvaged and used in the manufacture of specialty papers and plastic components. The flax straw that is not removed from the field, for these uses, is normally burnt or chopped and spread. Unfortunately burning has negative environmental impacts and chopping and spreading has an economic cost.

There is increasing interest in utilizing the flax straw that is presently uncollected. Recent market surveys and on-going research indicate that there are many potential products that could utilize flax fibers to complement or replace glass, synthetic and cotton fibers. If flax fibers were used more extensively in such products, it would increase the demand for flax straw, reduce the amount of flax straw that is burnt, and increase farmers' income from growing flax.

However, processing flax straw into industrial-grade fiber is not always profitable because of variations in fiber content and fiber yield. An inexpensive, accurate and rapid method of determining fiber content in flax straw is needed to help farmers, processors, flax breeders and potential investors profitably grow and process flax fiber in the province. The Agricultural Development Fund (ADF) of Saskatchewan Agriculture, Food and Rural Revitalization and the Saskatchewan Flax Development Commission (SaskFlax) have funded projects that enabled Biolin Research Inc. of Saskatoon to work with the USDA's Russell Research Lab in Athens, Georgia from 1999 to 2002 to develop a proto-type Near InfraRed (NIR) system to estimate the bast fiber content in unretted flax stems.

In this project, the database of NIR scans that was used to develop the original proto-type NIR system of bast fiber estimates was modified and improved by the addition of "non-redundant" (i.e., new) scans from types of flax straw that had not been recorded before. This was done in the winter of 2002/2003 on flax straw samples collected from research plots across Saskatchewan and Manitoba in the fall of 2002. A manual bast fiber extraction procedure previously developed by Biolin Research served to

check the results of the NIR procedure. In cases where there was a large divergence between the NIR estimate and the manual method estimate, technical staff considered reasons why the divergence may have occurred and then tried to improve the protocols that were used. The NIR estimates are still not as good as we would like but they have improved considerably as a result of this project and will continue to improve, as we continue to refine protocols and build a more complete data base of non-redundant scans.

Objectives of the Study

The objectives of this study were to:

1. Give producers, processors, breeders and potential investors the information they require to create profitable flax fiber based industries in Saskatchewan, and

2. Determine how a processor's fiber yields can be affected by location, variety and agronomic practices.

Experimental Methods

- 604 straw samples were collected from seven regional variety trial sites in Saskatchewan and from five regional variety trial sites in Manitoba in the fall of 2002 after the seed was harvested. In total, the straw of 22 flax varieties was collected, although no single site had all 22 varieties. Straw was collected from sites in Manitoba because the Crop Development Centre decided to abandon five regional flax variety trial sites in Saskatchewan due to abnormal drought conditions and the subsequent poor performance of the flax at these sites.

- During seed harvest of the plots, the cutting bar of the plot harvester was raised such that it just cut below the seed bolls. This was done to maximize the length of straw left standing to obtain an indication of the maximum yield of straw that could be obtained if flax was "straight cut" instead of being swathed.

- After the seed was harvested, four ¼ meter square sub-samples of flax straw were taken at random from each plot and blended together to make one sample.

- The samples were transported to Saskatoon.

- The samples were weighed and the weight was converted to kg/ha of salvaged straw for future use in calculating fiber yield/ha.

- Sub-samples were prepared for NIR and manual fiber content analysis. A sub-sample bundle of straw 4.0 cm in diameter was taken from each straw sample collected. Each sub-sample was cut to 19 cm in length, bound with two elastic bands and tagged with a plastic-coated label.

- All sub-samples were analyzed for bast fiber content using a NIR machine (FOSS 6500) located at the Crop Development Centre of the University of Saskatchewan. This was done by taking the straw from each sub-sample and scanning and re-arranging it five times to create a five scan average for each sub-sample. Software then used a database of historical scans to convert, as precisely as possible, the new sub-sample scans to bast fiber content readings.

- Selected sub-samples were also processed using a manual method to extract bast fiber. This involved warm water retting of some of the previously NIR scanned sub-samples for four to six days until the results of the "Fried Shake Test" showed that the majority of bundles were optimally retted. In the "Fried Shake Test" fifteen pieces of retting straw, each approximately 10.0 cm in length, each from a different bundle, were placed in fifteen test tubes half full of boiling water with one piece of straw in each test tube. The test tubes were stoppered and placed in a machine designed by Biolin Research to violently shake test tubes for 15 seconds. After shaking, the straw in each test tube was visually scored for loose fibers on a whole number scale from "0" to "3" with "0" representing no loose fibers and "3" representing total loosening of all bast fibers on the stem. When the average score was above 2.8 and there were no "0" scores and at least twelve test tubes had a score of "3", the bundles in the batch were considered fully retted. The bundles were then taken out of the tank, rinsed in tap water and set in drying racks, next to heater fans, for approximately four days to dry. Dry bundles from these selected retted samples were weighed and the fiber was extracted using a reciprocating blade-type breaker/decorticator. The fiber was hand cleaned to the point where few or no shives were left. After cleaning, the fiber was weighed and placed in separate sample bags and labeled with a catalog number. The bast fiber content was then expressed as a percent of the unretted stems by taking the weight of the extracted clean, retted fiber and dividing by the original weight of the unretted stems in the sub-sample in question and multiplying by 100. The resulting data was then compared with the original data from NIR analysis.

- Differences between the NIR and manual method estimates of bast fiber content were noted. An expert in NIR analysis was consulted regarding these differences and what could be done to reduce them.

- Data generated from the salvaged straw weights and the NIR scans was entered into Excel spreadsheets. The fiber yield in kg/hectare was calculated from the fiber content results and salvaged straw weights.

- The data was analyzed using regression methods with binary variables to determine if there are statistically significant relationships between laboratory-determined fiber contents and yields, varieties and locations of oilseed flax production in Saskatchewan and Manitoba. The reader should note that the most common statistical method used to analyze data from agronomic trials is Analysis of Variance. In general, when analysis of variance is used, it only shows if a particular result is significantly different from other results. Regression analysis is another statistical tool that can be used to pinpoint significant differences in the results of agronomic trials. In the past, regression analysis was often not done because it required significantly more computing power than was readily available to most agronomists. However, with the advent of personal computers and spreadsheets with regression analysis features, regression analysis is becoming the preferred method of analyzing agronomic data because it not only shows if the results are significantly different, it also estimates the size of these differences.

- A report was written summarizing the findings and conclusions of this study.

Results and Discussion

Appendix B contains printouts of the data resulting from the collection, preparation and fiber yield determination of samples of 22 oilseed flax varieties collected from twelve variety trials in Saskatchewan and Manitoba in 2002. Appendix A presents the results of regression equations that

were run on the data in Appendix B to identify explanatory variables that have a statistically significant impact on bast fiber content and yield. The equations that are presented in Appendix A were selected as being those that make best use of the data that was generated from the 2002 trials.

Sources and Usefulness of Oilseed Flax Straw Samples in 2002

It was initially expected that oilseed flax straw would be available from regional variety trials at 13 sites in Saskatchewan. Samples were collected from trial sites at Assiniboia, Battleford, Girvin, Kernen (Saskatoon), Luseland, Melfort and Rosthern. However, sites at Carlyle, Elrose, Wynyard, Nipawin, Hagen and Shellbrook received so little rain that either the trials were destroyed before seed harvest or there was no straw to salvage after the seed was harvested. Straw samples from Manitoba Agriculture variety trial sites at Hamiota, Portage, Stonewall, Thornhill and Emerson were collected to replace the straw that was not available in Saskatchewan. The extremely dry conditions at many sites in Saskatchewan mean that the results may not indicate the fiber contents or yields to be expected in more normal years. We do not know how much bias and misleading information was generated by the dry conditions.

The Saskatchewan sites each had thirteen conventional oilseed flax varieties and five solin varieties (Melfort had one additional flax variety, Norlin). The Manitoba sites each had straw available from 6 to 8 of the same varieties as the sites in Saskatchewan and from up to 4 varieties that were not tested at the Saskatchewan sites (Emerson, Norlin, Serenade and LW 2005-2). In total, 604 straw samples were collected for analysis representing 22 varieties and 12 sites. For most varieties, straw samples were available from 3 replications at each site, although for varieties used as checks in the trials (Vimy in Saskatchewan and usually Norlin in Manitoba) more samples were available (see Appendix B).

The fact that the Manitoba sites did not provide samples of as many varieties as the Saskatchewan sites and included some varieties not included in the Saskatchewan tests means that less comparative information is available on some varieties and that samples from fewer locations that represent Saskatchewan conditions were tested. Originally, plans were made to collect from Manitoba sites that were likely to have the most similar soil and long term climatic conditions to those in Saskatchewan but when Biolin staff got to some of these sites, the straw had already been destroyed due to poor communication between the administrators of the sites and the technicians who were actually harvesting the sites for seed.

The additional Manitoba samples do provide useful comparative information because of the different growing conditions that occurred in Manitoba in 2002 compared to the Saskatchewan sites (less dry) and contributed non-redundant data to the NIR database. This, in turn, will improve the accuracy of future NIR estimates of bast fiber content. This is because the accuracy of the estimates given by a NIR system are influenced, a great deal, by the comprehensiveness of the data that is available in the reference database used by the software. When a sample is scanned, the software checks to find scans in the database that are most similar to the scan just produced. Each scan in the database has associated with it, a bast fiber content that was estimated using a manual method. Thus the more non-redundant (i.e., new and different) fiber scans in the database, the more accurate will be the software's estimate of fiber content of a newly scanned sample.

Variance of Test Results (NIR versus the Manual Method)

All test and sampling methods have associated with them sources of variance. These are often referred to as "sources of error" or the "error term". This term represents the reality that test and sampling results will generally not be exactly the same even when the same test is repeated on the same material being tested. Highly refined test methods and/or test and sampling methods that have been used for long periods of time generally have smaller error terms than newly developed test and sampling

methods. This is because, as time goes on, test method protocols are generally improved upon so then become more accurate. The NIR and manual methods used in this project to test for bast fiber content are both very new test methods and hence both have relatively large error terms associated with them. Whether or not the size of the error term is "reasonable" or "acceptable" very much depends on the objective of the test and the alternative methods that are available to obtain that same objective. In the case of bast fiber content in flax straw, there appears, at the present time, one main objective or purpose. This is to enable the ranking of flax straw samples to determine if they have high, medium or low fiber content. Such ranking is needed by processors who need to select straw for processing from fields that have high or medium fiber content. It is also needed by farmers who want to select varieties most likely to give them a desired level of fiber content and by flax breeders who are now starting to consider bast fiber content as a selection criteria when developing varieties.

Initially the accuracy of our NIR method is constrained by the accuracy of our manual method. As time goes on and more and more "non-redundant" samples are added to our NIR database, we expect that the accuracy of the NIR method will exceed that of the manual method. This is because the protocol for the NIR method is much simpler that for the manual method and hence there are fewer occasions for human and machine error or mistakes to enter into the estimate of bast fiber content.

At the present time, the error term surrounding our manual and NIR estimates is about 2%, plus or minus the estimated fiber content. In other words, if our estimated fiber content is shown as 20%, the actual or "true" fiber content will almost always lie between 18% and 22% (i.e., from 20% - 2% to 20% + 2%). Similarly if our estimated fiber content is 8%, the true fiber content is likely to be between 6% and 10%. With time and improvement to protocols, our estimates should come closer and closer to the true fiber content.

One then needs to ask if an error term of 2% is precise enough for the present applications of the bast fiber tests used in this project? The answer would appear to be "yes" for two reasons. First, there are no other alternative tests for bast fiber content at this time, that are any more accurate. Second, we have found bast fiber content in flax straw can range from less than 2% to more than 40%. This is a very large range compared to our present error term of 2%. Hence both our NIR and manual method tests should be good enough at the present time, to almost always, at least distinguish between high, medium and low levels of bast fiber in samples of flax straw. This should be sufficient for most of the potential uses of this test. Further refinement and improvements in precision would be beneficial to flax breeders who may be trying to develop smaller incremental improvements to bast fiber content and to straw buyers who may eventually wish to pay farmers a bonus based on the bast fiber content in their straw.

In our manual method there are a number of sources of variance and sampling error. Some of the more important and/or more common are listed below:

- Different varieties mature at somewhat different times, however, all the straw at one location is cut and harvested on the same day and all the samples from one site are normally retted together in one tank until the majority have reached the optimal retting point. All the straw is then removed and dried prior to blade decortication. Since some varieties are not as mature and/or not retted to the same degree as others, their bast fibers do not come out as clean or free; hence the calculated fiber content can vary above or below what its "true" value is.

- It is difficult to judge how much waxy cuticle has come off during the final combing and cleaning process. If the samples are manually combed too much most of the cuticle comes off but small fibers are lost with the shives. If not enough combing is done, waxy cuticle (which is hard to see)

remains on the fibers and increases the weight of the fiber extracted and, hence, increases the estimated fiber content of the sample.

- It is tedious, time consuming and expensive to clean every piece of shive from every piece of fiber and every piece of little fiber from every shive. Technicians usually make a judgement call as to when the weight of fiber is unlikely to change if any more shives are removed from the fibers or any more fibers are cleaned out of the shives (i.e., so few impurities left that the weight of the majority substance will not change). Since this is a judgement call, it will vary with the technician involved and even with the mood they are in.

- When bast fibers are extracted from straw, dust is produced. The amount of dust produced can easily vary from one to five percent, or even more. This dust is a combination of the spores and remains of micro-flora and tiny pieces of straw and fiber. The amount of dust produced from a sample is not a consistent percentage since it depends on things like the relative humidity of the air and the straw, the vigor of the operator in using the mechanical blade decorticator, the type and number of retting organisms that grew on the straw, the strength and elasticity of the fiber and shives, etc.

- Bast fiber content is calculated by taking the weight of clean bast fiber and dividing by the original weight. To the extent that some of the dust was in fact bast fiber, the calculations will underestimate the bast fiber content, especially when the bast fiber content is relatively low.

- Our manual method also has a number of steps that require the technician to weigh and record weights and do mathematical calculations. From time to time, tedium, lack of attention and distractions set in and the technician will write down a wrong digit or invert numbers. We have tried to estimate the amount of test variance or error that is associated with our manual method but this has proved challenging. Much of this challenge can be attributed to the fact that such estimates normally involve the extraction of fiber from two or more subsamples of the same big sample. The degree to which the results from the two samples agree is supposed to indicate the amount of test error that exists. However, this assumes that the properties of the two subsamples were identical to start with. In the case of flax straw, we are still searching for a mixing protocol that can insure that a large sample is blended and mixed so well that any two samples drawn from it will have identical properties. Furthermore, our manual method destroys the straw when the fiber is extracted so we have no way of going back afterwards to check if the subsamples being tested were originally identical in properties.

The NIR protocol will also have variance or error associated with it. The following is a short list of some of the factors that can cause such variance in NIR protocols.

- The NIR machine is not set up or operated properly (e.g., inappropriate settings may be accidentally turned on, room temperatures or humidity fluctuate too much, dust gets into machine or sample holder, etc.)

- Calibration results based on manual method results may be incorrect and/or been entered incorrectly in the calibration database.

- The straw being tested may contain chemical substances or micro-organisms that are undetected but affect part of the spectra under consideration.

- The straw samples may not be properly and/or consistently mixed, prepared or placed in the sampling box.

- Conversion factors in the software convert spectral readings into estimates of bast fiber content based on manual results. There may be unknown errors in the conversion factors and/or in the manual method results that are being used.

We are continuing to try to eliminate or reduce these possible sources of error but realize that there will always be a test variance or error term associated with our results. The goal then is to reduce it and learn to take it into account when presenting results.

Results by Location

Table 1 presents the fiber content, fiber yield and seed yield from each location. The results are presented as index numbers with index number 100 at each location being the average of all varieties at that location. The data on which the index numbers are based is found in Appendix B.

The four sites with the highest average fiber contents were Portage (12.3%), Luseland (11.5%), Battleford (11.4%), and Girvin (11.3%), while the four lowest average fiber contents were found at Hamiota (6.3%), Treherne (7.0%), Thornhill (8.0%) and Melfort (8.0%). The four sites with the highest average fiber contents had an average fiber content that was 1.6 times greater than the average fiber content of the four sites with the lowest average fiber content. The average fiber content of the highest average fiber location (Portage) was almost double the lowest average fiber location (Hamiota) (see Table 1).

The four locations with the highest average fiber yield were Girvin (158 kg/ha), Portage (156 kg/ha), Thornhill (130 kg/ha) and Luseland (97 kg/ha), while the lowest average fiber yields were found at Melfort (18 kg/ha), Kernen (25 kg/ha), Treherne (43 kg/ha), and Rosthern (47 kg/ha). The four sites with the highest average fiber yield had an average fiber yield that was 4.1 times greater than the fiber yield at the four sites with the lowest average fiber yield. The average fiber yield at Girvin (highest) was 8.8 times greater than at Melfort (lowest) (see Table 1).

For almost all varieties at all locations, the fiber contents of the samples were lower than 15%, the minimum level generally considered profitable for processing. Only in a few samples from Girvin (AC Watson, 15.7%, and SP2100, 16.6%) and Portage (AC Hanley, 15.5%) did any variety have an average fiber content greater than 15%. However, the average fiber content for all varieties at Girvin and Portage was, respectively, only 11.3% and 12.3%.

The reader should note that these results are not as negative as they seem at first glance. In other research work recently completed by Biolin Research, it was found that the bast fiber content in baled straw is, on the average, about 5% higher than in the standing straw that was cut and used to make the bales. This apparent increase in fiber content is due to the fact that non-fiber parts of the stem often break off and fall out of the bale chamber as baling takes place due to the vigorous mechanical action of the baler. Thus if a processor needs about 15% bast fiber to breakeven in his processing operation, bast fiber contents in standing straw of 10% or more should give him bales with a bast fiber content of roughly 15%.

Based on Regression Equation 1 (see Appendix A) that combined the results of all 12 locations, the average fiber contents at ten of the locations were statistically different from the average at the "intercept" location (i.e., Assiniboia). These statistically significant differences were, no doubt, due to the cumulative and interactive effects of many different factors at each location (e.g., soil fertility, dates

of seeding, growing conditions, herbicide applications, etc.). Some of these conditions may determine the long-term fiber production potential of an area, while others may be related to the specific and unusual growing conditions of 2002.

The four sites with the highest average salvageable straw yields were Thornhill (1,661 kg/ha), Girvin (1,380 kg/ha), Portage (1,217 kg/ha) and Stonewall (949 kg/ha). These sites had an average straw yield that was 3.2 times greater than the average straw yield at the four sites with the lowest straw yields which included Kernen (229 kg/ha), Melfort (232 kg/ha), Rosthern (534 kg/ha), and Treherne (618 kg/ha). The average salvageable straw yield at Thornhill was 7.3 times greater than that at Kernen (see Appendix A, Equation 3).

The following list shows statistically significant differences that were isolated by the use of regression analysis among varieties at specific locations.

Assiniboia *(using Vimy as intercept)*

- Fiber contents were significantly lower in CDC Arras (-1.8%), AC Hanley (-2.1%), Linola 2047 (-2.4%), and Linola 989 (-2.9%) (equation 18).
- Cut straw lengths were significantly longer in AC Lightning (+8 cm), CDC Normandy (+7 cm), MacBeth (+6 cm), SP2099 (+6 cm), Prairie Blue (+5 cm), CDC Bethune (+4 cm), Linola 1084 (+4 cm), AC Carnduff (+4 cm), CDC Arras (+3 cm), CDC Mons (+3 cm), Linola 989 (+3 cm), and AC Watson (+3 cm) (equation 19).
- Salvageable straw yield was significantly less in SP2100 (-274.67 kg/ha) (equation 20).
- Fiber yields were significantly lower in SP2100 (-28 kg/ha), AC Hanley (-29 kg/ha), CDC Arras (-30 kg/ha), and Linola 989 (-33 kg/ha) (equation 21).

Battlefords *(using Vimy as intercept)*

- Cut straw lengths were significantly longer in Taurus (+9 cm) (equation 22).
- Fiber contents were significantly lower in AC Carnduff (-1.6%), Prairie Blue (-2.2%), CDC Mons (-2.5%), Taurus (-2.6%), and Linola 2047 (-3.4%) (equation 23).
- Salvageable straw yield was significantly higher in Taurus (+651 kg/ha) (equation 24).
- Fiber yield was significantly higher in Taurus (+46 kg/ha) (equation 25).

Girvin *(using Vimy as intercept)*

- Cut straw lengths were significantly longer in MacBeth (+7 cm), CDC Arras (+6 cm), Linola 2047 (+5 cm), CDC Bethune (+5 cm), SP2099 (+4 cm), Taurus (+4 cm), Linola 1084 (+4 cm), Prairie Blue (+4 cm), Linola 989 (+4 cm), AC Carnduff (+4 cm), and CDC Mons (+4 cm) (equation 26).
- Fiber contents were significantly higher in SP2100 (+8.4%), AC Watson (+7.4%), AC Hanley (+6.0 %), and CDC Bethune (+4.3%) (equation 27).
- Salvageable straw yields were significantly higher in CDC Mons (+409 kg/ha), Linola 2047 (+375 kg/ha), MacBeth (+360 kg/ha), and CDC Bethune (+350 kg/ha) (equation 28).
- Fiber yields were significantly higher in AC Watson (+138 kg/ha), CD Bethune (+96 kg/ha), SP2100 (+96 kg/ha), Linola 2047 (+94 kg/ha), AC Hanley (+85 kg/ha) and CDC Mons (+77 kg/ha) (equation 29).

Luseland *(using Vimy as intercept)*

- Fiber contents were significantly higher in AC Watson (+2.1%), SP2100 (+2.1%), and Linola 1084 (+1.2%), and were significantly lower in CDC Mons (-1.2%), AC Lightning (-1.2%), and Linola 2047 (-1.7%) (equation 30).

- Salvageable straw yield was significantly lower in AC Hanley (-407 kg/ha) (equation 31).

Melfort *(using Vimy as intercept)*

- Fiber contents were significantly higher in SP2100 (+3.8%), AC Hanley (+2.7 %), and Linola 1084 (+2.6%) (equation 32).
- Salvageable straw yield was significantly higher in AC Watson (+182 kg/ha) (equation 33).
- Fiber yield was significantly higher in AC Watson (+21 kg/ha) (equation 34).

Rosthern *(using Vimy as intercept)*

- Cut straw lengths were significantly higher in Taurus (+6 cm) and CDC Normandy (+4 cm) (equation 35).
- Fiber contents were significantly lower in CDC Arras (-1.5%), AC Lightning (-1.8%), and MacBeth (-2.0 %) (equation 36).
- Salvageable straw yields were significantly higher in CDC Bethune (+422 kg/ha), Prairie Blue (+322 kg/ha), and CDC Mons (268 kg/ha) (equation 37).
- Fiber yields were significantly higher in Prairie Blue (+42 kg/ha), CDC Bethune (+29 kg/ha), and CDC Mons (24 kg/ha) (equation 38).

Hamiota *(using Norlin as intercept)*

- Fiber content was significantly lower in Taurus (-3.0%) (equation 39).
- Fiber yield was significantly lower in Taurus (-28 kg/ha) (equation 40).

Portage La Prairie *(using Norlin as intercept)*

- Cut straw length was significantly lower in CDC Mons (-3 cm) (equation 41).
- Fiber contents were significantly higher in AC Hanley (+6.3%), Prairie Blue (+3.3%), and Linola 1084 (+2.3%) (equation 42).
- Salvageable straw yield was significantly lower in Linola 2047 (-323 kg/ha) (equation 43).
- Seed yields was significantly lower in Linola 2047 (-284 kg/ha), (equation 44)
- Fiber yields was significantly higher in Prairie Blue (+51 kg/ha), but significantly lower in Linola 2047 (-47 kg/ha) (equation 45).

Stonewall *(using Norlin as intercept)*

- Fiber content was significantly higher in CDC Mons (+3.0%) (equation 47.
- Fiber yield was significantly higher in CDC Mons (+40 kg/ha) (equation 48).
- Seed yields were significantly lower in AC Lightning (-296 kg/ha), AC Hanley (-304 kg/ha), Emerson (-337 kg/ha) and Linola 2047 (-588 kg/ha) (equation 49).

Thornhill *(using Norlin as intercept)*

- Fiber contents were significantly higher in Emerson (+5.0%), Serenade (+3.8%), AC Hanley (+3.8%), and Prairie Blue (+3.2%) (equation 50)
- Salvageable straw yields were significantly lower in MacBeth (-491 kg/ha) and Emerson (-560 kg/ha) (equation 51).
- Seed yields was significantly higher in AC Hanley (+386 kg/ha) and CDC Mons (+300 kg/ha) but significantly lower in Emerson (-457 kg/ha) (equation 53).
- Fiber yields was significantly higher in Prairie Blue (+94 kg/ha) and Serenade (+75 kg/ha) (equation 51).

***Treherne** (using Norlin as intercept)*

- Cut straw lengths were significantly lower in Linola 2047 (-3 cm), MacBeth (-3 cm), and AC Hanley (-4 cm) (equation 57).
- Fiber content was significantly lower in CDC Mons (-2.3%) (equation 58).
- Salvageable straw yield was significantly lower in MacBeth (-199 kg/ha) (equation 59).
- Seed yields were significantly higher in CDC Mons (+376 kg/ha), and MacBeth (+346 kg/ha) (equation 61).
- Fiber yields were significantly lower in CDC Mons (-22 kg/ha), and MacBeth (-24 kg/ha) (equation 60).

Table 1 - Fiber Content, Fiber Yield and Seed Yield Results Expressed as Index Numbers (page 1 of 3 pages)

	Area 1 – Brown			Area 2 - Dark Brown								
	ASSINIBOIA			GIRVIN			KERNAN			LUSELAND		
Variety	NIR Fiber Content	NIR Fiber Yield Based On Salvaged Straw	Seed Yield	NIR Fiber Content	NIR Fiber Yield Based On Salvaged Straw	Seed Yield	NIR Fiber Content	NIR Fiber Yield Based On Salvaged Straw	Seed Yield	NIR Fiber Content	NIR Fiber Yield Based On Salvaged Straw	Seed Yield
AC Carnduff	94	79	92	89	59	101	105	123	*N/A*	99	123	96
AC Emerson (check)	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
AC Hanley (FP 1094)	90	77	97	126	120	109	118	123	*N/A*	106	55	102
AC Lightning (FP 1069)	101	115	101	84	93	94	93	70	*N/A*	88	89	95
AC Watson	105	94	96	139	154	97	105	120	*N/A*	116	103	125
CDC Arras	93	76	98	101	103	85	89	59	*N/A*	106	101	107
CDC Bethune	97	99	107	111	127	107	96	184	*N/A*	93	136	125
CDC Mons (FP2044)	100	112	106	96	114	112	109	77	*N/A*	88	105	96
CDC Normandy	103	113	109	78	84	101	96	70	*N/A*	100	96	111
CDC Valour	111	98	100	111	107	114	104	119	*N/A*	99	96	105
LW 2005-2									*N/A*			
MacBeth (FP1096)	101	113	111	79	91	111	101	140	*N/A*	94	115	99
Norlin	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Prairie Blue (FP2024)	112	118	113	101	105	119	106	105	*N/A*	107	94	115
Serenade	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Taurus	95	97	102	83	86	106	76	48	*N/A*	96	87	107
Vimy	113	110	98	65	58	105	97	62	*N/A*	96	100	107
Solin												
Linola 989	81	86	92	80	107	73	97	61	*N/A*	101	144	91
Linola 1084	101	72	94	101	67	86	101	174	*N/A*	109	130	89
Linola 2047 (SP2047)	87	84	97	107	126	106	95	90	*N/A*	83	103	78
SP2099	103	92	100	100	107	93	105	92	*N/A*	103	97	64
SP2100	112	78	87	147	126	82	108	86	*N/A*	116	131	88
c.v.	49.5%	38.4%	6.2%	78.7%	60.0%	12.0%	64.2%	49.6%	0.0%	50.4%	45.6%	11.6%
Average	9.3%	91 (kg/ha)	1,629 (kg/ha)	11.3%	158 (kg/ha)	1,224 (kg/ha)	10.3%	25 (kg/ha)		11.5%	97 (kg/ha)	1,268 (kg/ha)
Index 100 = average of all varieties at a location												

Table 1 - Fiber Content, Fiber Yield and Seed Yield Results Expressed as Index Numbers (page 2 of 3 pages)

	Area 3 - Black											
	BATTLEFORD			ROSTHERN			MELFORT			HAMIOTA		
Variety	NIR Fiber Content	NIR Fiber Yield Based On Salvaged Straw	Seed Yield	NIR Fiber Content	NIR Fiber Yield Based On Salvaged Straw	Seed Yield	NIR Fiber Content	NIR Fiber Yield Based On Salvaged Straw	Seed Yield	NIR Fiber Content	NIR Fiber Yield Based On Salvaged Straw	Seed Yield
AC Carnduff	95	93	*N/A*	110	102	*N/A*	95	99	*N/A*	*N/A*	*N/A*	*N/A*
AC Emerson (check)	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	86	78	88
AC Hanley (FP 1094)	105	88	*N/A*	96	76	*N/A*	124	75	*N/A*	115	81	81
AC Lightning (FP 1069)	100	101	*N/A*	86	72	*N/A*	96	110	*N/A*	92	84	109
AC Watson	100	59	*N/A*	93	67	*N/A*	114	204	*N/A*	*N/A*	*N/A*	*N/A*
CDC Arras	101	99	*N/A*	89	53	*N/A*	90	90	*N/A*	*N/A*	*N/A*	*N/A*
CDC Bethune	108	124	*N/A*	96	146	*N/A*	82	100	*N/A*	125	125	111
CDC Mons (FP2044)	87	116	*N/A*	106	137	*N/A*	110	134	*N/A*	124	147	115
CDC Normandy	105	75	*N/A*	100	106	*N/A*	97	81	*N/A*	*N/A*	*N/A*	*N/A*
CDC Valour	102	84	*N/A*	97	101	*N/A*	85	89	*N/A*	*N/A*	*N/A*	*N/A*
LW 2005-2	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
MacBeth (FP1096)	101	104	*N/A*	83	73	*N/A*	109	90	*N/A*	94	86	100
Norlin	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	92	79	*N/A*	107	115	93
Prairie Blue (FP2024)	90	102	*N/A*	123	175	*N/A*	81	68	*N/A*	128	136	113
Serenade	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Taurus	86	153	*N/A*	90	108	*N/A*	87	88	*N/A*	56	47	95
Vimy	111	102	*N/A*	114	84	*N/A*	88	93	*N/A*	*N/A*	*N/A*	*N/A*
Solin												
Linola 989	103	106	*N/A*	103	90	*N/A*	100	95	*N/A*	*N/A*	*N/A*	*N/A*
Linola 1084	111	90	*N/A*	106	83	*N/A*	123	132	*N/A*	*N/A*	*N/A*	*N/A*
Linola 2047 (SP2047)	79	103	*N/A*	99	104	*N/A*	94	107	*N/A*	71	57	95
SP2099	105	102	*N/A*	108	72	*N/A*	97	95	*N/A*	*N/A*	*N/A*	*N/A*
SP2100	111	116	*N/A*	101	84	*N/A*	138	82	*N/A*	*N/A*	*N/A*	*N/A*
c.v.	56.7%	37.4%	0.0%	62.9%	51.3%	0.0%	53.1%	57.0%	0.0%	34.8%	34.1%	11.7%
Average	11.4%	84 (kg/ha)	-	8.4%	47 (kg/ha)	-	8.0%	18 (kg/ha)	-	6.3%	51 (kg/ha)	1,877 (kg/ha)

Index 100 = average of all varieties at a location

Table 1 - Fiber Content, Fiber Yield and Seed Yield Results Expressed as Index Numbers (page 3 of 3 pages)

	Area 3 - Black (Continued)											
	PORTAGE			STONEWALL			THORNHILL			TREHERNE		
Variety	NIR Fiber Content	NIR Fiber Yield Based On Salvaged Straw	Seed Yield	NIR Fiber Content	NIR Fiber Yield Based On Salvaged Straw	Seed Yield	NIR Fiber Content	NIR Fiber Yield Based On Salvaged Straw	Seed Yield	NIR Fiber Content	NIR Fiber Yield Based On Salvaged Straw	Seed Yield
AC Carnduff	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
AC Emerson (check)	*N/A*	*N/A*	*N/A*	100	97	94	137	98	46	*N/A*	*N/A*	*N/A*
AC Hanley (FP 1094)	127	110	97	100	93	95	121	105	141	105	93	93
AC Lightning (FP 1069)	93	90	104	97	92	96	91	100	67	91	93	106
AC Watson	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
CDC Arras	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
CDC Bethune	97	99	106	101	109	103	83	99	111	113	111	102
CDC Mons (FP2044)	99	92	102	112	127	107	92	107	131	72	72	110
CDC Normandy	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
CDC Valour	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
LW 2005-2	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	88	70	99	*N/A*	*N/A*	*N/A*
MacBeth (FP1096)	*N/A*	*N/A*	*N/A*	96	88	102	93	65	126	82	68	109
Norlin	87	88	100	83	86	108	74	77	97	104	123	93
Prairie Blue (FP2024)	114	121	106	106	116	110	115	149	91	133	133	103
Serenade	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	121	135	76	*N/A*	*N/A*	*N/A*
Taurus	*N/A*	*N/A*	*N/A*	102	93	102	88	96	89	108	107	95
Vimy	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Solin												
Linola 989	106	103	94	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Linola 1084	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Linola 2047 (SP2047)	78	58	91	103	108	84	96	100	126	92	81	90
SP2099	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
SP2100	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
c.v.	**52.3%**	**53.6%**	**5.7%**	**50.2%**	**51.9%**	**7.8%**	**55.7%**	**51.7%**	**19.0%**	**50.9%**	**61.7%**	**7 4%**
Average	**12.3%**	**156 (kg/ha)**	**2,983 (kg/ha)**	**10.5%**	**98 (kg/ha)**	**2,472 (kg/ha)**	**8.0%**	**130 (kg/ha)**	**889 (kg/ha)**	**7.0%**	**43 (kg/ha)**	**2,183 (kg/ha)**
Index 100 = average of all varieties at a location												

Results By Crop Production (Soil Zone) Area

For ease of presentation and to provide more useful comparisons for readers by narrowing the range of comparison to locations with similar climate and soil characteristics, production locations were grouped into one of three Crop Production Areas (Table 2). Crop Production Area 1 corresponds to the Brown Soil Zone, Area 2 to the Dark Brown Soil Zone and Area 3 to the Black Soil Zone. Fiber content for each variety is expressed as an index number based on the average area fiber content. The same is done for seed yield. The reader should keep in mind that, in 2002, there were very significant differences in weather patterns among locations in a given soil zone and hence the aggregated soil zone results need to be treated with great caution.

- In Area 1, the variety with the highest fiber content (Vimy) had a fiber content that was 40% greater than the lowest fiber content variety (Linola 989).

- In Area 2, the highest fiber content variety (SP2100) had a fiber content that was 46% higher than the lowest fiber content variety (Taurus).

- In Area 3, the highest fiber variety (Linola 1084) had a fiber content 56% higher than the lowest (LW2005-2).

Table 3 highlights those varieties in each crop area that had both higher fiber content and higher seed yield than the average fiber content and seed yield of all varieties at all locations in the crop area. Varieties that combine high seed and high fiber content would be of great interest to both farmers and processors of flax straw, since seed production is likely to remain the primary focus of these producers.

- In Area 1, AC Lightning, CDC Normandy, MacBeth and Prairie Blue had both superior seed yield and superior fiber content compared to the area average.

- In Area 2, AC Hanley, AC Watson, AC Valour and Prairie Blue were superior in both seed yield and fiber content.

- In Area 3, AC Hanley, Prairie Blue and Linola 1084 were superior in both seed yield and fiber content.

- AC Hanley was superior in two areas while Prairie Blue was superior in all three areas.

Table 2 – Relative Fiber Content of Varieties by Soil Zone (Saskatchewan and Manitoba Variety Trials, 2002)

	---Fiber Content as Index of Average---			---Seed Yield as Index of Average---		
Variety	**Area 1**	**Area 2**	**Area 3**	**Area 1**	**Area 2**	**Area 3**
AC Carnduff	94	98	102	92	98	N/A
AC Emerson (check)	N/A	N/A	99	N/A	N/A	78
AC Hanley (FP 1094)	90	117	111	97	106	107
AC Lightning (FP 1069)	101	88	93	101	94	111
AC Watson	105	120	104	96	111	N/A
CDC Arras	93	99	96	98	96	N/A
CDC Bethune	97	100	99	107	116	118
CDC Mons (FP2044)	100	97	99	106	104	122
CDC Normandy	103	91	104	109	106	N/A
CDC Valour	111	105	98	100	110	N/A
LW 2005-2	N/A	N/A	78	N/A	N/A	47
MacBeth (FP1096)	101	91	89	111	105	105
Norlin	N/A	N/A	86	N/A	N/A	110
Prairie Blue (FP2024)	112	105	108	113	117	118
Serenade	N/A	N/A	107	N/A	N/A	36
Taurus	95	85	84	102	106	96
Vimy	113	86	108	98	106	N/A
Solin						
Linola 989	81	93	104	92	82	N/A
Linola 1084	101	104	122	94	87	150
Linola 2047 (SP2047)	87	95	88	97	92	103
SP2099	103	103	106	100	79	N/A
SP2100	112	124	118	87	85	N/A
Site Average (% or kg/ha)	**9.3%**	**11.0%**	**9.1%**	**1,629**	**1,246**	**1,874**
Index 100 = average of all varieties within an area						

Table 3. Flax Varieties Exhibiting Both Above Average Fiber Content and Seed Yield (Saskatchewan and Manitoba Variety Trials, 2002)

	AREA 1		AREA 2		AREA 3	
	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)
AC Camduff	94	92	98	98	102	N/A
AC Emerson (check)	N/A	N/A	N/A	N/A	99	78
AC Hanley (FP 1094)	90	97	117	106	111	107
AC Lightning (FP 1069)	101	101	88	94	93	111
AC Watson	105	96	120	111	104	N/A
CDC Arras	93	98	99	96	96	N/A
CDC Bethune	97	107	100	116	99	118
CDC Mons (FP2044)	100	106	97	104	99	122
CDC Normandy	103	109	91	106	104	N/A
CDC Valour	111	100	105	110	98	N/A
LW 2005-2	N/A	N/A	N/A	N/A	78	47
MacBeth (FP1096)	101	111	91	105	89	105
Norlin	N/A	N/A	N/A	N/A	86	110
Prairie Blue (FP2024)	112	113	105	117	108	118
Serenade	N/A	N/A	N/A	N/A	107	36
Taurus	95	102	85	106	84	96
Vimy	113	98	86	106	108	N/A
Solin						
Linola 989	81	92	93	82	104	N/A
Linola 1084	101	94	104	87	122	150
Linola 2047 (SP2047)	87	97	95	92	88	103
SP2099	103	100	103	79	106	N/A
SP2100	112	87	124	85	118	N/A
Site Average (% or kg/ha)	**9.3%**	**1,629**	**11.0%**	**1,246**	**9.1%**	**1,874**

NOTE White squares = Higher than average fiber content AND higher than average seed yield

Index 100 = average of all varieties within an area

Table 4 highlights those varieties in each crop area that had lower fiber content and higher seed yield than the average fiber content and seed yield of all varieties at all locations in the crop area. Flax varieties with low fiber content and high seed yield would be of interest to producers of oilseed flax who do not have opportunity to add value to their flax straw. Seed production will be the primary focus of these producers and they will be interested in low fiber straw to reduce the difficulties in disposing of straw that cannot be sold.

- In Area 1, CDC Bethune and Taurus had low fiber content and high seed yield.
- In Area 2, CDC Mons, CDC Normandy, MacBeth, Taurus and Vimy had low fiber content and high seed yield.
- In Area 3, AC Lightning, CDC Bethune, CDC Mons, MacBeth, Norlin and Linola 2047 had low fiber content and high seed yield.

Regression analysis pinpointed the following statistically significant differences (using Area 1 as intercept):

- Cut straw length was significantly longer in Area 3 (+3 cm) (equation 62).
- Fiber content was significantly higher in Area 2 (+1.2%) (equation 63).
- Fiber yield was significantly lower in Area 3 (–17 kg/ha) (equation 64).

Provincial Differences

- Saskatchewan locations, on average, provided longer straw than Manitoba locations, based on cut straw length (+1.17 cm) (Equation 6) and higher fiber content (+1.6%) (Equation 5).
- Manitoba locations, on average, had higher straw yields than Saskatchewan locations (+351 kg/ha) (Equation 7) and higher fiber yields (+17 kg/ha) (Equation 8).
- In Saskatchewan the variety with the highest fiber content was SP2100 (12.0%) and the lowest, by 1.6 times, was Norlin (7.4%), (equation 9). CDC Bethune had the highest cut straw length (27 cm). The lowest, by 1.7 times, was Norlin (16 cm) (equation 10). The highest straw yield was CDC Bethune (893 kg/ha) and the lowest, by 3.7 times, was Norlin (209 kg/ha) (equation 11).
- When looking at varieties that were included in BOTH the Crop Development Centre and Manitoba programs, fiber content ranges from the high AC Hanley (11.0%) to a low of Norlin (7.6%)(equation 14); cut straw length ranges from a high of 28cm (Linola 1084) to a low of 23cm (MacBeth) (equation 15); salvageable straw yield ranges from 1,234 kg/ha (Linola 1084) to a low of 832 kg/ha (MacBeth) (equation 16); and fiber yield ranges from 160 kg/ha (Linola 1084) to a low of 60 kg/ha (MacBeth) (equation 17).

Table 4. Flax Varieties Exhibiting Low Average Fiber Content and High Average Seed Yield (Saskatchewan and Manitoba Variety Trials, 2002)

	AREA 1		AREA 2		AREA 3	
	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)
AC Carnduff	94	92	98	98	102	N/A
AC Emerson (check)	N/A	N/A	N/A	N/A	99	78
AC Hanley (FP 1094)	90	97	117	106	111	107
AC Lightning (FP 1069)	101	101	88	94	93	111
AC Watson	105	96	120	111	104	N/A
CDC Arras	93	98	99	96	96	N/A
CDC Bethune	97	107	100	116	99	118
CDC Mons (FP2044)	100	106	97	104	99	122
CDC Normandy	103	109	91	106	104	N/A
CDC Valour	111	100	105	110	98	N/A
LW 2005-2	N/A	N/A	N/A	N/A	78	47
MacBeth (FP1096)	101	111	91	105	89	105
Norlin	N/A	N/A	N/A	N/A	86	110
Prairie Blue (FP2024)	112	113	105	117	108	118
Serenade	N/A	N/A	N/A	N/A	107	36
Taurus	95	102	85	106	84	96
Vimy	113	98	86	106	108	N/A
Solin						
Linola 989	81	92	93	82	104	N/A
Linola 1084	101	94	104	87	122	150
Linola 2047 (SP2047)	87	97	95	92	88	103
SP2099	103	100	103	79	106	N/A
SP2100	112	87	124	85	118	N/A
Site Average (% or kg/ha)	**9.3%**	**1,629**	**11.0%**	**1,246**	**9.1%**	**1,874**

NOTE White squares = Lower than average fiber content AND higher than average seed yield

Index 100 = average of all varieties within an area

Conclusions and Impact

Conclusions

We do not know how much bias and misleading information was generated by the dry conditions in Saskatchewan but there were significant differences between Saskatchewan and Manitoba fields on a whole. Varieties do often influence fiber content and hence farmers can influence fiber content of oilseed flax by their choice of variety. However, more years of data are needed to improve our ability to predict which varieties will generally be superior.

There was a wide range of fiber contents in the straw tested in 2002. Given such a wide range of fiber contents, it is very important for processors and producers of flax straw and breeders of flax varieties to have methods that will allow them to quickly choose straw that has superior fiber content.

Both the NIR and manual methods of bast fiber determination used in this project would be suitable, in most cases, to distinguish straw with high, medium or low bast fiber contents but neither test method is highly precise. Hence both methods need more refinement to make them more accurate.

Impact

The reader should keep in mind that fiber yield is related to both fiber content of the plants and the total yield of straw. High fiber content in a year where low biomass is produced may not produce enough fiber per acre to make collection profitable for processors.

It is obviously very important for processors of flax straw to be able to choose only straw that will be profitable for them to collect (i.e., have high enough fiber content and yield). The results of the tests carried out in this project indicate that variety and location of production often influence fiber content. Farmers, thus, can influence fiber content by their choice of variety, based on the location of production. Biolin's manual and NIR methods of testing flax samples for fiber content provide a basic, essential testing and assessment tool for producers, processors and potential investors who seek to develop a fiber industry in Saskatchewan. Continuing testing for fiber content of oilseed flax varieties grown in various locations in the province and continuing research work to identify and assess the factors that contribute to fiber content should be a priority if the private sector and governments wish to increase the number and size of firms engaged in value adding activities that are based on flax straw and flax fiber.

Assuming weather plays a large role in determining fiber content and, hence, that a particular location that produces high fiber content straw in one year will not necessarily produce high fiber content straw the next year, processors will likely find it necessary to collect straw from widely separated and different locations in different year and/or to store high fiber content straw over several seasons to meet their needs.